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BULLETIN NO. 16.

EFFECT OF FOOD ON COMPOSITION OF BUTTER FAT.

PART I.—COMMON FEEDING STUFFS.
PART II.—VARIOUS OILS USED IN RATIONS.

SEPTEMBER, 1892.

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EFFECT OF FOOD ON THE COMPOSITION OF BUTTER.

PART I.

In May, 1891, this station issued Bulletin No. 13, in which the above subject was touched upon, but no definite conclusions were given. Since then the work has been carried on as opportunities have occurred, and a variety of rations have been tried with interesting and, we hope, valuable results. Nearly all these rations were such as may be fed on any farm in the state, and an effort has been made to find out that ration which would most probably produce the best butter.

The experiments may be divided into two series. In the first series, constant amounts of hay and ensilage were used in all the rations, while the amounts and kinds of grain were varied. In the second series, the quantities of ensilage and grain remained the same in all rations; but the kind and quantity of hay or dry fodder was changed.

The cows used in the experiments were of different breeds, and were in different stages of lactation; but the influences of those characteristics were either neutralized or accounted for in the end. For convenience the two series will be described separately.

THE FIRST SERIES

was begun May 19, 1891, and continued through the following June and July.

THE COWS

are described in the following table, which shows the arrangement in groups, breed, and length of time in milk:

Group I.	Aurora, 2nd.	Shorthorn.	Milked since March, '91.
	Clio.	Ayrshire.	Milked since August, '90.
Group II.	Duchess of Hanover.	Shorthorn.	Milked since March, '91.
	Frost.	Ayrshire.	Milked since Sept., '90.
Group III.	Chinchilla.	Ayrshire.	Milked since April, '91.
	Maramee.	Holstein.	Milked since May, '90.
Group IV.	Duchess.	Shorthorn.	Milked since Sept., '90.
	Duchess, 2nd.	Shorthorn.	Milked since June, '90.

THE ANALYSIS OF THE BUTTER

was confined to the determination of the volatile, fatty acids and the iodine absorption of the purified butter-fat. This course was pursued because the fat is that part of the butter which is least influenced by the processes of the dairy-man, and therefore best shows the effect of the food upon the cow. Furthermore, the flavor of butter undoubtedly depends in great measure upon the quantity of volatile fatty acids present in the butter-fat, and its firmness has been shown to be closely connected with the amount of oleic acid, which in its turn has been shown to be related to the amount of iodine absorbed by the butter-fat. In general, a butter of a high flavor has a larger amount of volatile acids than one of low flavor, and a soft butter absorbs a greater amount of iodine than a hard butter.

THE GROUPS WERE FED

in the first period of this series, a ration containing mixed grain consisting of equal parts of corn meal, cotton-seed meal, gluten meal, and middlings. In the second and third periods, groups I and II were fed to compare the relative effects of corn meal and gluten meal, while groups III and IV were used to find out the action of cotton-seed meal. After the first three periods, the groups were broken by dropping Aurora, Clio, Frost, and Maramee from the experiment, and the series was continued with the remaining cows, individually. But as the cows had been tested individually in the previous periods, as well as in groups, the change would not affect the results.

THE COMPOSITION OF THE FEEDING STUFFS

was determined by analyzing a part of them, and by reference to the table in Bulletin No. 4, page 16, for the remainder. The results of the analyses are shown in the following table :

	Water.	Ash.	Crude Protein.	Crude Fiber.	Nitrogen free extract.	Fat.	Nutritive Ratio.
Corn meal.........	14.25	1.15	8.96	1.69	70.19	3.76	1:8.55
Cotton-seed meal...	8.52	6.91	41.44	7.00	23.40	12.73	1:1.35
Cream gluten meal.	8.22	1.84	39.68	1.55	32.59	16.12	1:1.82
*Wheat gluten meal	7.58	1.09	82.72	0.25	7.41	0.95	1:0.12

THE COMPOSITION OF THE RATIONS

is shown in detail in the next table, which gives the amount of food used for a cow weighing one thousand pounds. Each ration is designated at the top of the column by a letter (a, b, c), which serves to distinguish it in the succeeding tables where the effect of the food on the butter is shown :

THE NEXT TABLES

in order give the details of feeding-periods, with the ration fed, the date of taking the sample, the group or cow, and composition of the butter. The figures for volatile acids signify the number of cubic centimeters of deci-normal barium hydroxid solution, which are equivalent to the volatile acids in five grammes of butter-fat. The iodine number means the number of parts of iodine absorbed by one hundred parts of butter-fat. (This explanation of the figures is given for the satisfaction of other chemists who may read this article, and is as clear as can be given in a few words.)

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* From Atlantic Starch Works, Brooklyn, N. Y.

TABLE OF RATIONS.

Pounds of Food per 1,000 lbs. Live Weight.

Ration.	a.	b.	c.	e.	g.	h.	j.
Ensilage.........	40.	40.	40.	40.	40.	40.	.....
Hay............	5·5	5·5	5·5	5·5	....	....	......
Grass...........	....	....	....	....	13·5	13·5	......
Middlings.......	2.05	2·35	2·35	2·4	2·35	2·35	2.05
Corn meal.......	2.05	6.	....	....	6.	5·	2.05
Cotton-seed meal	2.05	....	....	7·25	....	....	2.05
Gluten meal.....	2.05	....	5·3	....	....	....	2.05
Wheat gluten....	....	....	....	....	....	15¼ oz.	......
Pasturage.......	....	....	....	....	....	....	ad libitum.
Nutritive ratio...	1 : 5.2	1 : 8.8	1 : 4.5	1 : 3.9	1 : 7.5	1 : 5.5	1 : 3.4*

TABLE SHOWING EFFECT OF FOOD. GROUPS.

Period of Feeding.	Ration.	Date of Sample	Group I.		Group II.		Group III.		Group IV.	
			Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.
Preparatory	a	June 1	30.2	38.2	32.9	35.0	29.0	39.0	30.8	38.7
June 2	b	" 15	29.6	33.3	.....	.....	......	.....	......	......
to	c	" 15	.....	.....	29.3	41.3	......	......	......	......
June 16.	e	" 15	.....	.....	.....	.....	.....	......	24.4	34.7
June 16	c	" 29	27.1	42.1	.....	.....	.....	......	......	......
to	b	" 29	.....	.....	29.0	31.6	......	......	......	......
July 2.	e	" 29	.....	.....	.....	.....	25.4	33.4	......	......

* Estimated.

TABLE SHOWING EFFECTS OF FOOD. INDIVIDUALS.

Feeding Period.	Ration.	Date of Sample.	Aurora.		Clio.		Duchess of H.		Frost.		Chinchilla.		Duchess.		Duchess, 2d.	
			Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.
Preparatory.	a	June 1	31.4	38.1	26.6	34.8	32.1	33.4	26.4	35.3	28.7	38.3	31.0	36.4	28.9	39.3
June 2	b	" 9	32.0	32.5	......	......	......	......	......	......	......	......	......	......	......	......
		" 15	30.1	35.5	24.6	30.4	......	......	......	......	......	......	......	......	......	......
to	c	" 9	......	......	......	......	29.4	40.6	......	......	......	......	......	......	......	......
		" 15	......	......	......	......	28.6	41.3	23.8	41.6	......	......	......	......	......	......
June 16.	e	" 9	......	......	......	......	......	......	......	......	......	......	......	......	23.3	34.2
		" 15	......	......	......	......	......	......	......	......	......	......	23.5	33.7	21.4	34.5
June 16	c	" 23	29.3	42.3	......	......	......	......	......	......	......	......	......	......	......	......
		" 29	27.7	40.8	21.5	39.9	......	......	......	......	......	......	......	......	......	......
to	b	" 23	......	......	......	......	28.2	33.0	......	......	......	......	......	......	......	......
		" 29	......	......	......	......	29.6	28.8	......	30.0	......	......	......	......	......	......
July 2.	e	" 23	......	......	......	......	......	......	......	......	26.2	33.9	......	......	......	......
		" 29	......	......	......	......	......	......	......	......	26.5	31.9	......	......	......	......
July 2	g	July 7	......	......	......	......	29.1	29.8	......	......	......	......	......	......	......	......
		" 9	......	......	......	......	27.5	31.6	......	......	......	......	......	......	......	......
to	b	" 7	......	......	......	......	......	......	......	......	26.3	26.2	......	......	......	......
		" 9	......	......	......	......	......	......	......	......	24.9	25.7	......	......	......	......
July 10.	c	" 7	......	......	......	......	......	......	......	......	......	......	23.6	39.0	25.4	42.3
		" 9	......	......	......	......	......	......	......	......	......	......	25.1	40.7	27.8	44.8
July 10	h	" 12	......	......	......	......	29.2	30.3	......	......	......	......	......	......	......	......
to		" 14	......	......	......	......	29.5	29.3	......	......	......	......	......	......	......	......
		" 16	......	......	......	......	29.3	28.7	......	......	......	......	......	......	......	......
July 18.	c	" 12	......	......	......	......	......	......	......	......	26.6	33.8	......	......	......	......
		" 14	......	......	......	......	......	......	......	......	30.5	36.1	......	......	......	......
		" 16	......	......	......	......	......	......	......	......	31.1	36.1	......	......	......	......
July 18	j	" 20	......	......	......	......	32.1	34.7	......	......	29.1	36.7	......	......	......	......
to		" 24	......	......	......	......	33.9	36.6	......	......	29.8	38.2	20.4	40.5	23.6	40.3
		" 27	......	......	......	......	31.0	37.2	......	......	25.3	39.7	19.1	38.2	22.7	39.8
July 31.		" 31	......	......	......	......	30.2	38.8	......	......	26.5	39.8	22.5	40.4	21.3	41.2

The careful inspection of the table for individuals shows plainly, in the case of the four cows continuing through the experiment, that volatile acids decrease and that the iodine number increases as the period of lactation advances. These facts have been noticed by so many observers that they may be regarded as following a natural law. The inspection also shows the variation in both constituents of the butter from different cows when they are fed upon the same rations. This is especially noticeable in the last series of samples when the cows were at pasture. The variations are due, no doubt, both to peculiarities of breeds or individuals, and to the period of lactation. By referring to the description of the cows it will be seen that Duchess and Duchess, 2d, were of the same breed and in nearly the same stage of lactation. Duchess of Hanover and Chinchilla were also in nearly the same period of lactation, but were of different breeds.

The influence of breed may be left out in studying the effect of the food, but the influence of the period of lactation must be carefully considered.

It has already been mentioned that the rations in this series contained the same quantities of hay and ensilage, but varied in the kind and amount of grain.

IN THE PREPARATORY PERIOD,

as has also been mentioned, the ration (a) contained equal quantities of each grain, and served to show the variations due to breed and period of lactation, and also as a starting point with which to com pare the different rations.

CORN MEAL AND GLUTEN MEAL

were fed in rations (b) and (c) respectively, and were used with groups I and II and with the different cows individually. Ration (b) was fed to group I after (a), to group II after (c), and the individuals of the groups, Aurora, Clio, Duchess of H., and Frost, were tested separately at the same time; it was fed to Chinchilla, after ration (e), the cotton-seed meal ration. In no case has it changed the volatile acids from their natural decrease; but in each case the iodine number has been *decreased*, which is *opposed* to the natural progress of lactation and *must be due to the food.*

Ration (c) was fed to group I after (b), and to group II after (a), and the cows were also tried individually. In three trials it had no effect on the volatile acids; but the iodine number was increased so sharply that the increase must have been partly due to the food and not wholly to the advance of lactation. It was fed to Chinchilla after (b) and to Duchess and Duchess, 2d, after (e). These trials also showed the same action upon the iodine number, and gave an increase in the volatile acids likewise, which will be further mentioned.

COTTON-SEED MEAL

was fed in ration (e) to groups III and IV after (a), and the individuals of the groups Chinchilla, Duchess, and Duchess, 2d, were compared at the same time. The iodine number was very much *depressed* in each case and the volatile acids also, with the exception of Chinchilla. Now it may be noticed that the increase of volatile acids after feeding gluten meal (c) was in each case preceded by the feeding of cotton-seed meal (e), or (e) and (b).

THESE RESULTS ARE IN ACCORD

with those given in Bulletin No. 13 and therefore our observations all show that corn meal had no effect on the volatile acids; but *lowered* the *iodine number*; gluten meal affected the volatile acids only after they had been depressed by some other food, when it raised them, while the *iodine number* was *raised* in every case; cotton-seed meal *lowered both* volatile acids and iodine number.

GREEN GRASS WAS COMPARED WITH HAY

by feeding rations (g) and (h) after ration (b).

It was tried upon only one cow, Duchess of Hanover. Ration (g) was like ration (b), except that the hay of the latter was replaced by its equivalent of grass. This ration caused no appreciable variation in the butter-fat. Ration (h), which followed ration (g), had a portion of its corn meal replaced by wheat-gluten meal, a nearly pure albuminoid substance. The effect of this ration was to increase the volatile acids slightly; while the iodine number was slightly decreased. Ration (j) contained no grain, consisting wholly of pasture-grass. A study of the samples from three of the four cows, showed no change in either volatile acids or iodine number which could not be attributed to the advance of lactation.

Grass *did not*, in general, *affect* the *composition* of the *butter*, which fact corresponds with recent German investigations.

THE SECOND SERIES

of experiments was begun on January 2d, 1892, with seven cows, and various kinds of hay or dry fodder were compared. The cows were arranged in four sets or groups as follows :

Group I.	Duchess.	Shorthorn.
	Duchess, 2d.	Shorthorn.
Group II.	Pilot's Lily.	Jersey.
	Princess Leto.	Jersey.
Group III.	Maramee.	Holstein.
Group IV.	Chinchilla, Jr.	Ayrshire.
	Frost, Jr.	Ayrshire.

The rations, as before remarked, contained the same kinds and quantities of grain, but varied in the amount and variety of hay. They were calculated from the table in Bulletin No. 4, of this station, and are given in the following table, where each ration is designated by a number at the top of the column :

TABLE OF RATIONS.

Pounds of Food per 1,000 lbs. live weight.

Ration.	1	2	3	4	5	6	7
Ensilage	50	50	50	50	50	40	50
Middlings	2½	2½	2½	2½	2½	2½	1⅔
Gluten meal	1¼	1¼	1¼	1¼	1¼	1¼	......
Cotton-seed meal	1¼	1¼	1¼	1¼	1¼	1¼	......
Corn meal	......	......	......	......	......	2½	3⅓
Mixed hay	5	......	......	10	......	8	10
Oat hay	5	......	......	......	10	......	......
Clover hay	......	10	......	......	......	......	......
Vetch hay	......	......	10	......	......	......	.....
Nutritive ratio	1 : 6	1 : 5.2	1 : 4.7	1 : 6.2	1 : 5.8	1 : 6	1 : 9.8

THE FEEDING PERIODS

were three in number, the preparatory period of two weeks, the second period of two weeks, and the third period of four weeks.

THE SAMPLES OF BUTTER

were taken near the ends of the first and second periods, and in the middle and at the end of the third period. Following is the table showing the periods, rations, and composition of the butter, similar to the tables in the first series :

TABLE SHOWING EFFECT OF FOOD.

Feeding Period.	Ration.	Date of Sample.	Group I.		Group II.		Group III.		Group IV.	
			Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.
Preparatory	1	Jan. 12	30.5	34.4	28.9	26.4	31.0	31.5	27.8	32.7
January 14	2	" 27	33.4	33.7	.....	.....	.....	.....	.....	.....
to	3	" 27	.....	.....	29.2	28.3	.....	.....	.....	.....
	4	" 27	.....	.....	.....	.....	32.4	31.8	.....	.....
January 28.	5	" 27	.....	.....	.....	.....	.....	.....	27.4	32.9
January 28	4	Feb. 10	33.2	32.9	.....	.....	.....	.....	.....	.....
		" 24	32.1	36.0	.....	.....	.....	.....	.....	.....
to	6	" 10	.....	.....	30.2	27.7	.....	.....	.....	.....
		" 24	.....	.....	29.4	29.9	.....	.....	.....	.....
February 26.	7	" 10	.....	.....	.....	.....	30.0	30.4	.....	.....
		" 24	.....	.....	.....	.....	30.8	36.0	.....	.....
	2	" 10	.....	.....	.....	.....	.....	.....	28.0	35.7
		" 24	.....	.....	.....	.....	.....	.....	27.5	37.7

In the first five rations there are compared mixed hay or English hay, clover hay, dry oat-fodder, and vetch hay. In the two last rations the nutritive ratio of the mixed hay ration (4) is widened by the addition of corn meal and dropping out gluten meal and cotton-seed meal.

THE PREPARATORY RATION,

or ration (1), contained mixed hay and oat fodder. The variation of the volatile acids and iodine number, due to other causes than food, may be seen in the table, along the first line.

Vetches (3) and oat fodder (5) were tried but once in each case. The former was fed to group II after (1) and the latter was fed to group IV in the same order. Neither produced any apparent change in volatile acids. Clover hay (2) was fed to groups I and IV, and in each case the *volatile acids were increased*, which is contrary to the observed facts for progress of lactation, and should be attributed to the food. In the case of group IV there appears to be but a very slight increase, but in a month the advance of lactation usually lowers the volatile acids appreciably.

Mixed hay (4) was fed to groups I and III. With group III it followed the preparatory ration and *increased* the *volatile acids*; with group I it followed clover hay (2) and kept the volatile acids at the high point to which the clover hay had raised them.

Rations (6) and (7) caused no appreciable change in the composition of the butter-fat from the previous rations, unless the constancy of volatile acids with group II is considered equivalent to an increase, which may be attributed to the mixed hay.

In general, since the *oat fodder* was fed in the preparatory ration and in (5), it appeared in this series that it caused a *lower amount* of *volatile acids* in the butter-fat, than was the case with clover hay or mixed hay.

The sinking of volatile acids and rising of the iodine number with the advance of lactation, was again seen in this series in the last period, where the two samples of butter were taken with an interval of two weeks between them. Group III was an exception in the case of the volatile acids.

There is to be noted in conclusion that some of the results of this scientific investigation are in accord with the practice of many dairy-men who produce a high grade of butter. A favorite ration with them is corn meal and clover or mixed hay.

Corn meal has been shown to produce a butter-fat with a low iodine number, corresponding to a hard, firm butter. Clover hay and mixed hay have produced a butter-fat with a high figure for volatile acids, which is equivalent to a high flavor.

Nevertheless, corn meal and clover hay are not the only suitable foods for producing a firm, highly flavored butter, and the study of this bulletin should show other combinations even better.

EFFECT OF FOOD ON THE COMPOSITION OF BUTTER.

PART II.

The experiments described in the following pages were a continuation of those described in Part I, and were carried out for the purpose of throwing some light upou the action of different food constituents, as the proteids or albuminoids, starch and fat, upon the composition of the butter-fat.

THE CONTINUATION OF THE FIRST SERIES

consisted of comparisons of corn meal with gluten meal and cornstarch, and comparisons of whole cotton-seed with cotton-seed meal and cotton-seed oil.

Gluten meal represented the albuminoids of the corn meal, and also contained the fat. The whole cotton-seed was ground to a coarse meal, which therefore contained the lint, hulls, oil, and albuminoids. Cotton-seed meal represented the albuminoids, as the hulls and oil are removed as thoroughly as possible, previous to the grinding. The cows were the same as described in the first part and need no description here.

THE COMPOSITION OF THE FEEDING-STUFFS

has already been given in part, but for convenience in comparing them, they are repeated here in connection with the analysis of the cotton-seed.

COMPOSITION OF FEEDING STUFFS.

	Water.	Ash.	Crude Protein.	Crude Fiber.	Nitrogen, free ext' ct	Fat.	Nutritive Ratio.
Corn meal..........	14.25	1.15	8.96	1.69	70.19	3.76	1:8.55
Cream gluten........	8.22	1.84	39.68	1.55	32.59	16.12	1:1.82
Cotton-seed meal	8.52	6.91	41.44	7.00	23.40	12.73	1:1.35
Cotton-seed..........	7.55	5.00	18.72	22.18	25.27	21.28	1:4.70

The starch was assumed to be pure, as was also the cotton-seed oil, and they were not analyzed.

THE FOLLOWING TABLES

are arranged as in the preceding part, to describe the rations and the results of the different trials. Some of the figures have already been used; but are repeated for greater convenience in studying the experiments.

TABLE OF RATIONS.

Pounds of Food per 1,000 pounds live weight.

Ration.	a	b	c	d	e	f	i	j
Ensilage............	40	40	40	40	40	40	40	......
Hay................	5.5	5.5	5.5	5.5	5.5	5.5	5.5	......
Middlings...........	2.05	2.35	2.35	2.25	2.40	2.25	2.35	2.05
Corn meal...........	2.05	6.	......	......	......	......	......	2.05
Gluten meal.... ...	2.05	......	5.3	......	......	3.5	1.83	2.05
Cotton seed.........	......	......	......	6.25	......	......	......	......
Cotton seed.........	2.05	......	......	......	7.25	......	......	2.05
Cotton-seed oil.....	......	......	......	......	......	oz. 13.5	......	......
Starch.....	......	......	......	......	......	......	3.4	......
Pasturage..........	......	......	......	......	......	......	......	ab libitum.
Nutritive ratio.....	1:5.2	1:8.8	1:4.5	1:7.1	1:3.9	1:6.2	1:8.4	* 1:3.4

* Estimated.

Feeding Period.	Ration.	Date of Sample	Group III.		Group IV.		Chinchilla.		Duchess.		Duchess, 2d.	
			Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.
Preparatory	a	June 1	29.0	39.0	30.8	38.7	28.7	38.3	31.0	36.4	28.9	39.3
June 2	d	" 9	.....	.....	....	....	20.6	34.2	....	....	......	....
to	d	" 15	19.3	34.7	....	....	21.9	33.6	....	....	......	....
	e	" 9	.....	.....	....	....	....	....	....	....	23.3	34.2
June 16.	e	" 15	.....	.....	24.4	34.7	....	.....	23.5	33.7	21.4	34.5
June 16	e	" 23	.....	.....	....	....	26.2	33.9	....	....	......	....
to	e	" 29	25.4	33.4	....	....	26.5	31.9	....	....	......	....
	d	" 23	.....	.....	....	....	....	.....	....	....	20.1	32.6
July 2.	d	" 29	.....	.....	21.2	32.9	....	.....	18.2	32.0	19.5	30.1
July 2	b	July 7	.....	....	....	....	26.3	26.2	....	....	......	....
to	b	" 9	.....	.....	....	....	24.9	25.7	....	....	......	....
	c	" 7	.....	.....	....	....	....	.....	23.6	39.0	25.4	42.3
July 10.	c	" 9	.....	.....	....	....	....	.....	25.1	40.7	27.8	44.8
	c	" 12	.....	.....	....	....	26.6	33.8	....	....	......	....
July 10	c	" 14	.....	.....	....	....	30.5	36.1	....	....	......	....
	c	" 16	.....	.....	....	....	31.1	36.1	....	....	......	....
	f	" 12	.....	.....	....	....	....	.....	21.6	35.0	......	....
to	f	" 14	.....	.....	....	....	....	.....	18.0	38.3	......	....
	f	" 16	.....	.....	....	....	....	.....	19.6	40.2	......	....
	i	" 12	.....	.....	....	....	....	.....	....	....	25.3	38.1
July 18.	i	" 14	.....	.....	....	....	....	.....	....	....	27.3	35.0
	i	" 16	.....	.....	....	....	....	.....	....	....	27.9	37.2
July 18	j	" 20	.....	.....	....	....	29.1	36.7	17.6	36.9	25.6	38.8
to		" 24	.....	.....	...	....	29.8	38.2	20.4	40.5	23.6	40.3
July 31.		" 27	.....	.....	....	....	25.3	39.7	19.1	38.2	22.7	39.8
		" 31	.....	.....	....	....	26.5	39.8	22.5	40.4	21.3	41.2

THE COMPARISON OF COTTON-SEED

with cotton-seed meal was made upon the groups III and IV, and three of the cows in the groups were tested individually. With group III, the cotton-seed ration (d) preceded the cotton-seed meal (e).

The iodine number was steadily lowered ; but, while cotton seed lowered the volatile acids from 29.0 to 19.3, the meal raised them from 19.3 to 25.4 ; the same phenomenon was also noticed with Chinchilla alone.

With group IV the order was reversed, and there was a steady decrease in both iodine number and volatile acids. The former decrease, as already explained, was contrary to the advance of lactation, while the decrease of volatile acids was so sharp that it must have been partly caused by the food. Comparing the rate of change in both constituents, for each substance, cotton seed influenced the composition of the butter, more than the cotton-seed meal.

CORN MEAL WAS FED

to Chinchilla, in ration (b) after cotton-seed meal ration (e). The figures have already been mentioned, but attention is again called to the lowering of the iodine number and the non-interference with the natural decrease of the volatile acids.

GLUTEN MEAL, RATION (C)

was fed to Duchess and Duchess, 2d, after cotton-seed (d), and to Chinchilla after (b). Part of these figures have been used before, and it will be recalled that the gluten meal increased the iodine number abnormally and also raised the volatile acids, when it followed a food which had caused them to decrease.

COTTON-SEED OIL

was fed in ration (f) combined with gluten meal, and followed gluten meal, ration (c), with Duchess.

There was a decided lowering of the volatile acids, judging by the preceding and following periods, which was apparently due to the oil ; but the iodine number was not changed much. Applying the comparison with the preceding and following periods, it appeared to have been, on the whole, slightly retarded from the normal rate of increase.

CORN STARCH

was combined with gluten meal in ration (i) in such proportion that the ration was equivalent to the corn-meal ration (b).

It followed gluten meal (c) with Duchess, 2d, and produced the same effect as corn meal, decreasing the iodine number and causing no variation in the volatile acids.

THE CONTINUATION OF THE SECOND SERIES

was carried out with the cows Duchess, Maramee, and Princess Leto, which were used in the second series of Part I. The experiment consisted of trials of several oils or fats in rations containing a constant quantity of albuminoids and carbohydrates. The oils used in the series were corn or maize oil, cotton-seed oil, cocoanut oil, palm oil, commercial oleo oil, and commercial stearin. Since it was desired to observe especially the effect of corn oil and cotton-seed oil, the ration was compounded with a view to avoiding any of the products of cotton-seed or corn, other than the oils, and for this purpose, clover and vetch hay, oat-meal and middlings, together with ensilage, were used for the preliminary feeding, and the trial rations were made by adding equal quantities of the oils to the preliminary ration.

THE DIFFERENT RATIONS

and the results of the trials are given in the succeeding tables :

TABLE OF RATIONS.

Pounds of Food per 1,000 pounds live weight.

Ration.	8	9	10	11	12	13	14	15	16
Ensilage.......	23½	23½	23½	23½	23½	23½	23½	23½	23½
Clover hay.....	7½	7½	7½	7½	11¼	11¼	11¼	11¼	11¼
Vetch hay......	3¾	3¾	3¾	3¾	......	......	......	......	.....
Oat meal......	3¾	3¾	3¾	3¾	3¾	3¾	3¾	3¾	3¾
Middlings......	3¾	3¾	3¾	3¾	3¾	3¾	3¾	3¾	3¾
Palm oil.......	......	11 oz.	......	......	......	......	......	......	.....
Corn oil.......	......	......	11 oz.	......	......	......	......	......	.....
Cotton-seed oil.	......	......	......	11 oz.	......	......	......	11 oz.	.....
Stearine........	......	......	......	......	......	11 oz	......	......	.....
Olein.	......	......	......	......	......	......	11 oz.	......	.....
Cocoa-nut oil..	......	......	......	......	......	......	......	......	11 oz.
Nutritive ratio.	1 : 5.9	1 : 6.7	1 : 6.9	1 : 7	1 : 6.2	1 : 6.9	1 : 7	1 : 7	1:6.9

Feeding Period.	Ration.	Date of Sample.	Duchess.		Maramee.		Princess Leto.	
			Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.	Volatile Acids.	Iodine Number.
Preparatory........	8	March 13	33·1	33·0	31·3	33·5	29·0	28·4
March 16	9	" 27	31·5	34·8	......	......	......	......
to	10	" 27	......	......	......	......	28·4	38·1
	11	" 27	......	......	25·2	41·9	......	......
March 31.	11	" 31	......	......	27·3	43·6	......	......
March 27–31.......	12	" 31	......	......	......	......	27·6	32·3
March 31 to April 16.	13	April 14	28·0	35·6	......	......	......	......
	14	" 14	......	......	......	......	30·7	31·6
April 16 to April 27.	15	" 27	29·6	37·6	......	......	......	......
	16	" 27	......	......	......	......	29·8	24·2
Pasture...........		May 26 July 4	32·5 29·9	35·0 39·4	....	....	33·8 32·7	30·4 32·8

The inspection of the tables shows some interesting results, but owing to the small number of trials no law can be deduced from them.

PALM OIL.

was fed to Duchess, immediately after the preparatory ration, in ration (9), and there was no change in the volatile acids or the iodine number from the normal progress of lactation. Stearin, ration (15), was next fed and produced no effect on the iodine number, but by comparing the volatile acids with the two preceding periods and with those following, especially the pasture period of July 4, nearly four months after the preparatory ration, it appeared that the volatile acids were decreased. By the same method of comparison, cotton-seed oil in ration (15) raised the iodine number, and while increasing the volatile acids over the stearin ration, did not make them of normal quantity. By the same line of reasoning palm oil had a similar effect to cotton-seed oil, though less noticeable. Cotton-seed oil in ration (11), fed to Maramee after the preparatory period, showed a very decided action upon the volatile acids and iodine number, and in the same direction as when fed to Duchess.

Corn oil was fed to Princess Leto in ration (10) after the preparatory period. There is no effect on the volatile acids, but the iodine number rose abruptly from 28.4 to 38.1. The ration (12) fed to Princess was used because the vetch hay had become exhausted. The only change was in feeding clover hay instead of equal parts of clover and vetch. The result was to bring the iodine number back to a more normal amount. Olein or oleo oil was next fed in ration (14) and produced a decided rise in the volatile acids, while the iodine number was slightly decreased. Cocoa-nut oil followed the olein and caused a sharp decrease in the iodine number. With Princess Leto, the pasture periods show a peculiar condition with regard to volatile acids, inasmuch that they are higher than in any period during the experiment, although from one to two months had elapsed.

SUMMING UP

the results of these trials, it was shown that the volatile acids were only slightly affected, but on the whole were decreased, by feeding fats. A comparison of the changes in the butter-fat with the volatile acids of the fats used in the rations, showed a striking result, and the comparison is here given :

Oil.	*Vol. Ac.*	*Change in vol. ac. of butter.*	
Cocoa-nut,	6.5	30.7 to 29.8	— 0.9
Corn,	3.2	29.0 to 28.4	— 0.6
Cotton-seed,	1.1	31.3 to 25.2	— 6.1
Palm,	1.7	33.1 to 31.5	— 1.6
Olein,	2.0	27.6 to 30.7	+ 3.1
Stearin,	1.4	31.5 to 28.0	— 3.5

With the exception of the olein, which increased the volatile acids over the previous ration, the fats caused the volatile acids of the butter to vary in the order of their own contents of volatile acids.

The iodine number was more affected by feeding the fats, and here again was a striking coincidence, which is shown in the following comparison of the oils and their action.

Oil.	*Iodine Number.*	*Change in iodine number of butter.*	
Corn,	112.8	28.4 to 38.1	+ 9.7
Cotton-seed,	106.1	33.5 to 41.9	+ 8.4
Palm,	52.2	33.0 to 34.8	+ 1.8
Cocoa-nut,	7.1	31.6 to 24.2	— 7.4
Olein,	47.5	32.3 to 31.6	— 0.7
Stearin,	24.1	34.8 to 35.6	+ 0.8

In this comparison it is shown that with the exception of the olein the fats caused the iodine number in the butter to vary in accordance with their own iodine numbers.

IN CONCLUSION

it was found that, of the constituents of corn meal, the gluten or albuminoids had the property of affecting the volatile acids in the butter-fat, while the starch and oil affected the iodine number, the former decreasing and the latter increasing it. Since gluten meal contained both oil and albuminoids, and the oil affected the iodine number as much as the gluten meal did, it was impossible to say that the albuminoids did or did not act on it.

Of the cotton-seed constituents, it was found that the oil and the meal, or nitrogenous part, affected the volatile acids alike ; but the iodine number was raised by the oil and lowered by the meal.

When fed all together in the original grain, cotton seed produced the effect of the meal or nitrogenous matter ; while corn produced the effect of the starch.

These trials with carbohydrates, albuminoids, and fats were not numerous enough to enable one to formulate a new theory from them or to overthrow old theories ; but they do not agree with the theory that milk fat is formed from the albuminoids only of the food constituents, and that fats in the food do not enter into the fat of the milk.

F. W. MORSE, *Chemist.*

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